

power, for our means are not sufficient to throw projectiles with several thousand metres velocity ; and it is very remarkable that this experiment comes at the same time as the interesting experiment of Prof. Lemström, showing that electric currents are able to give a development of light in our atmosphere, possessing the same number of undulations in a second as the auroral light. Now our meteoroid being a part of an aurora, it gives a stronger proof of the origin of that phenomenon than Prof. Lemström's experiment, the greatest attraction of which is that we are able to repeat it arbitrarily and with our own means. Further, I have always maintained that electricity, excited easily by friction, must be one of the causes of the auroral light ("Théorie Cosmique de l'Aurore Polaire," *Journal des Spectroscopistes Italiens*, 1878, vol. vii. chap. ii.), and it seems to me very plausible that cosmic matter, approaching the earth, induces electric currents through the air. Therefore I think that the results of Prof. Lemström are in full harmony with the idea of a cosmic origin of auroræ.

The orbit found does not reach the surface of the earth, being at its nearest approach still 1239 kilometres (1 mile = 1609·3 metres ; 1 German geogr. mile = 7420·4 metres) or 16·7 geogr. miles from that surface. The length of the orbit from the Utrecht perpendicular line to the Utrecht horizon is 1,483,070 metres, and this line being run over in 60 seconds,¹ the mean relative velocity was 24.673 metres, 15·3 miles, or more than 3 German geogr. miles.

The dimensions of the "cosmic cloud" (length 40°, width 5°, as seen from Ipswich) are : length = 182,594, width = 21921 metres. By these dimensions, probably too great from irradiation, it must show at Utrecht an apparent length of 50°; but the extremities were tapered and therefore the length strongly influenced by the transparency of the air. It is therefore not strange that the apparent length at Utrecht was during some few seconds 90 degrees.

To conclude, I will remark that the proved existence of a cosmic cloud, preserving its pretty sharp sides during so long a path as that from Sweden to the Atlantic Ocean, notwithstanding its velocity of 247 kilometres, proves its particles to be nearly spherical. Otherwise these particles should necessarily have diverged sideways from the orbit and spread into space. In connection with the fact observed by Mr. P. Zeeman (p. 297), that auroral clouds gave interference-phenomena, when coming before the moon's disk, and these latter phenomena requiring (Dagnin, "Traité de Phys." iv. p. 446) the presence of nearly equal particles of dusty matter, Mr. Zeeman's observation proves the same property in the particles of the auroral cloud. Being nearly equal, but not perfectly, the tangential atmospheric resistance must throw the smallest particles backward, and this explains the oblong shape of the cloud.

In presenting my results and reasonings to the readers of this journal, I hope that they will remember that this paper has been written in a shorter time than the author had wished.

H. J. H. GRONEMAN

Groningen (Netherlands), April 7

THE AURORA BOREALIS²

II.

THE Aurora Borealis at Sodankylä.—Although the aurora borealis often appeared with considerable intensity, it did not boast many varieties. It began generally with a faint arc in the northern sky, which soon developed into a sharp arc, with streamers and a kind of luminous "drapery" spreading from east to west. The colour of this luminous drapery was not very changeable, so that the spectroscope only returned the usual yellow-

¹ This number is stated also by the sharp determination given by the Astronomer Royal, Prof. Christie.

² Continued from p. 63.

green line. Generally it was of a yellow-whitish colour, with a slight shade of green.

There was, however, an observation made of far greater interest, viz. that the spectroscopic "reaction,"¹ i.e. $\lambda=5569$, on several occasions was returned from every quarter of the horizontal plane, even from the zenith, *without any aurora being visible*. As this reaction was obtained while the ground was still bare, there can be no question of its being a reflection, but that this place was at the moment within the sphere of an auroral discharge, but of such a weak character that it did not appear in the form of aurora borealis. This observation was therefore precisely similar to the one made in 1871 in Lapland, described above.

These observations were chiefly made by my assistant, Herr Biese, who made another remarkable discovery. Nearly due south-east from the Observatory, he received on several occasions a spectral reaction from a narrow belt of the sky, *although no aurora was visible*. This observation, which was very difficult to effect, as the eye had to be kept entirely away from all light for fully five minutes before the reaction could be traced, I had myself several opportunities of corroborating. In this direction were situated some mountains 300 metres high, about 30 kilometres distant, and in my opinion the reaction was due to the above-described phosphorescent flames, which were seen around the mountain-tops in Lapland and Spitzbergen. All observations were of course made after *every trace* of daylight had disappeared.

The Phosphorescent Luminosity.—On several occasions the attention of travellers in the Arctic regions has been attracted to a peculiar soft light or "shine" during the night. But, as the change from day to night is very gradual in the Polar regions, as compared with that of southern climes, a certain amount of exertion of the mind is required in order to take cognisance and retain the features of this phenomenon. As, however, attention has been once drawn to the same, it will always be observed. Already in October I noticed it at Sodankylä, and directed the attention of my assistants to it. I give subjoined some extracts from my diary concerning this phenomenon :—

December 9, 1882.—The Polar night shows sometimes a peculiar phosphorescent "shine" or diffused luminosity, which possesses several phases, but the general character of which is a luminosity of a yellow-white colour, which renders the night as light as the moon with a thick hazy air. I take here the appearance and disappearance of the light on two nights when its intensity was greatest.

On December 6 I was on a journey between Orajärvi and Sodankylä. The phenomenon became then apparent at 7 o'clock p.m. When daylight had completely disappeared, there seemed to remain a faint light in which the outlines of objects around could only with difficulty be discerned. At 7.40 this increased, however, so rapidly that in a few moments every object around stood out clearly in a yellow-white hazy phosphorescent luminosity of quickly-shifting intensity. I had unfortunately no Photometer by me by which I could determine the same. It lasted in this form until about 10 o'clock.

December 8, at 5 p.m., I walked from the Observatory to the church near it, in order to observe from its steeple some fire-signals from Oratunturi. On the way, I noticed that a yellow-white luminosity of shifting intensity filled the entire horizon, while twenty minutes after it had increased greatly in intensity, and was now strongest in the north, whence it gradually faded to the south, where it had least intensity. Near the horizon it was difficult to discern the stars. Higher up it was, however, easier, and from 60° to the zenith the sky was clear, of a mauve colour. It was exceedingly interesting to compare the light with the Milky Way. The yellow-white light

¹ By this term Prof. Lemström of course refers to the characteristic line in the spectrum of the aurora. The term might be justified by analogy with the "reactions" characteristic of the presence of the various chemical elements.—ED.

contrasted sharply with that of the latter, particularly where the Milky Way stood out of the same. In the yellow-white light it was difficult to make out the Milky Way. This phenomenon lasted far into the night. Later in the evening, between seven and nine, there appeared an aurora of great intensity, of which I shall speak below. This luminosity gave no reaction in the spectroscope at our disposal, but no doubt it would have been obtained had this been less absorbing. Thus, for instance, the larger Wrede's spectroscope (four prisms) did not give the reaction of the auroral phenomenon at Oratunturi, whereas the smaller, as stated above, really showed the line.

There is not the least reason for assuming that this luminosity is of any but an auroral nature, and the result of these observations is that the whole of northern Lapland is during most winter nights illuminated by a phosphorescent luminosity, whose intensity varies greatly according to period and place, but which is undoubtedly of an auroral nature.

On the same day, viz. December 8, the expedition was enabled to make the first measurement in the magnetic meridian of the elevation of the auroral arc. The wire, which was laid out north and south for the study of the terrestrial current, was used as a telephone line, and the observations thus made by signals. Two theodolites with the necessary instruments were employed, viz. one at Sodankylä and the other about 4·5 kilometres distant to the north, near the mouth of Kälujoki. The observations at the observatory were made by Herr Biese, and at the northern end of the telephone line by Herr Petrelius. The auroral arc appeared in the north and shone with a quiet, subdued light, while a streamer now and then shot forth into the sky. Six measurements were made with the following result:—At the northern station the line of sight formed, with the under rim of the arc and the horizontal plane, an angle of 9° , and at the southern station one of 12° , i.e. an angle 3° larger at the southern than at the northern station! Even assuming that both observers saw the same arc, the result is absurd, as however great the distance between the two might be, the difference of the angle would be very small indeed, and, if a difference at all, the angle of the northern station should have been the greatest. As, however, the reverse was the case, I have come to the conclusion that the two observers did not see the same aurora. A corroboration of this opinion is that on one occasion Herr Biese telephoned, "Turn the instrument to where the red column is," while at the northern station no such colour could be traced. This was proved still further during the return journey from Kultula to Sodankylä by the following circumstance. At Königä, 60 kilometres north of Sodankylä, on January 3, 1883, at 4 p.m., the whole horizon was flooded with a yellow-white luminosity of great intensity. At the same time an auroral arc formed in the south about 25° over the horizon, and a similar one was at the same moment observed at the same elevation in the north from Sodankylä. The departure from Königä took place just after 4 p.m., and during the journey this arc gradually disappeared, while the luminosity and the arc seen at Sodankylä were seen all through the evening. Here there was an opportunity of measuring the elevation of the auroral arc, but as I was convinced that the two phenomena were not the same, I did not attempt it.

It was clear that we were within an auroral discharge which extended considerably east and west, but the main strike of which was north and south. It is very probable that the electric current which caused this light some thousand metres above the surface of the earth also produced the above-described intense luminosity in a layer some 20 metres in depth, running parallel with the earth. It was this layer which was projected from both points into the sky in the shape of an arc. But it is clear that the auroral "drapery" did not penetrate far

into the horizontal plane, but as it is generally produced in the centre of a weak discharge of great penetration its appearance from various places in the line north and south would be very variable according as the layer lends its light to the drapery.

The measurements and results described above exactly correspond with those of Mr. Fritz in Greenland (*Bulletin de la Commission polaire Internationale; Mittheil. der Internationalen Polarcommission*, Heft 3), where he obtained an auroral drapery of 650 feet, 1700 feet distant from the observer, and another one of 170 feet, 350 feet distant.

Without further discussing this question here I must state that I consider that all measurements of the height of the aurora, calculated on those with a long base north and south, are always erroneous, as the two observers never see the same aurora. And even those calculations which are based on the measurements of the height and length of an arc from one point, and the hypothesis that the arc extends around the magnetic pole, must be considered very unreliable, as no satisfactory answer can be given as to what results would have been obtained a little further north or south. This is also the case with auroræ with long bases east and west, as only on a shorter distance is it possible to say if it is the same phenomenon which is seen.

That the height of the aurora borealis is very variable I fully admit, but in my opinion it has been greatly overestimated.

Researches with the Terrestrial Current.—During my expedition to Lapland in 1871, we examined the terrestrial current in two places, viz. Kittilä, lat. $67^{\circ} 40'$, and Enare Vicarage, lat. $68^{\circ} 55'$, with wires $1\frac{1}{2}$ kilometres long—east and west, north and south—of copper 0·4 mm. in diameter, and finishing in platina disks 10 cm. by 5 cm., buried in the earth at a depth of 0·7 to 0·9 metre. The deflection was measured by a galvanometer with astatic needles with telescope and scale (Weber's magnetometer, of Edlund's improved construction). The remarkable result obtained here was that the galvanometer at Kittilä, with the current east and west, gave a deflection equal to 60 to 100 parts of the meter scale, whereas the current at Enare only gave a fraction of one part of the meter. With the current north and south, the difference was not so great, although even here the deflections were smaller at Enare. It was unfortunately impossible to ascertain if this remarkable phenomenon was due to latitude or season, the researches at Kittilä being made in October, and those at Enare in the latter half of November, while on the former occasion the ground was not frozen, which it was on the latter.

The Finnish expedition this year to Sodankylä has also examined the terrestrial current, viz. during certain periods of the phenomenon every five minutes, at other times once every hour, with a wire 5 kilometres long, terminating in small platina disks in the earth. During my visit to Kuttala—December 22 to January 4—I also tested the terrestrial current, but with a wire only 1 kilometre in length, running east and west. Here, too, no deflection was shown, while in Sodankylä the current was just as strong as ever. At Kuttala the galvanometer was certainly not so sensitive as at Sodankylä, still, the experiments of 1871 are even in this respect not without importance.

I have, therefore, from these researches drawn the inference that, while the condition of the ground is of some influence, the terrestrial current ceases at a certain latitude. In 1871 already I maintained that the terrestrial current was caused chiefly by the electricity which descends from the atmosphere in the belt around the Pole, in which the aurora borealis attains its maximum, and my recent researches at Sodankylä have greatly confirmed this theory.

I now intend to discuss the conclusions I have come to from the above detailed researches.

Although the general belief as to the nature of the aurora borealis certainly is that it is of electric origin,

other theories have been advanced, as for instance by Grönemann, *Astr. Nachr.*, 1874-75, and the reason of this is, I believe, that hitherto no direct proof had been obtained demonstrating its true nature.

But the experiments at Luosmavaara in 1871, and at Oratunturi and Pietarintunturi in 1882, clearly and undeniably prove that the aurora borealis is an electric phenomenon.

The science of the physical conditions of the globe has hitherto, particularly as regards the electric and magnetic ones, simply advanced by observing the effects of these great forces of nature, without however any successful attempt having ever been made to influence or call them forth either directly or indirectly. My experiments now, however, prove that *aurora borealis may be produced in nature* by a simple contrivance assisting the electric current flowing from the atmosphere to the earth. And although the efforts of man must always be limited in comparison with the grand products of nature, the conclusions which may be drawn from the same are not the less instructive.

In a question wherein the theoretical deductions, supported only by a few indirect proofs, have but slowly advanced, *absolute certainty* has now been obtained, and this result should induce future students of the aurora borealis not to devote attention to the "light" phenomenon itself, but to the investigation of those wonderful forces of nature the existence of which it so "lucidly" demonstrates. We have, of course, much to learn from the light also, but far more, I believe, from the electric forces which create it.

It is, however, far from my intention to insist that the apparatus invented by me is the best or that the method followed may not be improved on; still it has certainly one advantage, viz. that of being effective. It is, of course, evident that the drawbacks under which the experiments suffered—as, for instance, weak wires and defective insulators—must be remedied, and it appears to me that the theory which is the basis of M. Mascart's insulator would be particularly suited to the apparatus. The galvanometer should also be altered so as to consist of a great number of well insulated coils, in order better to regulate the deflexions, and the experiments should be made in a warm room. As the electrometrical method hitherto used gives only the electric tension at a certain point, it would, it appears to me, form a good meter for measuring the electric state of the surrounding atmosphere. The galvanometer deflexions depend certainly on the electric potential, as well as on the variable conducting power of the air; but it can, as will be seen from my experiments, be measured and even divided by using a constant galvanic element. The electric condition thus measured will give us *an idea* of the strength of the electric current, which in a certain place descends to the earth, and of the electric changes which take place in the atmosphere.

From the experiments with the terrestrial current described above it seems very probable that the current is closely related to the electricity in the auroral belt. The terrestrial current is, as is generally known, related to the magnetic variations, which is most conclusively shown by Mr. Airy's curves (*Phil. Trans.*, vol. cxxxviii. p. 465). In Sodankylä disturbances of the terrestrial current were always followed by a magnetic one. The exact result has of course not yet been calculated, but a glance at the figures returned is sufficient to show this. Mr. Airy's researches have caused these questions: (1) Are the variations in the terrestrial currents more numerous than the corresponding magnetic ones? (2) Do the terrestrial variations occur about half an hour from the corresponding magnetic disturbances?

We have from the experience gained attempted to explain these peculiarities, viz. by the hypothesis that the earth forms, so to say, the core in a flexible bobbin, represented by the terrestrial current circulating around her.

In the first place, many of the changes to which the terrestrial current is subject could not affect the magnetic moment of the core, i.e. the earth; and, in the second place, the current acts directly on the instruments whereby the magnetic variations are measured; and in these circumstances we must find the explanation of the first-named peculiarity. With regard to the very remarkable difference in time of about *half an hour*, this is the exact time elapsing before the variations of the terrestrial current can affect the magnetic moment of the earth. It is, by the bye, only necessary to compare the duration of induction currents produced in bobbins with different iron cores, to observe that *half an hour* might well pass before the current became perceptible, if the earth constituted the core. In Polar regions the electric current descending from the atmosphere to the earth may also contribute to the variations which are measured by our instruments.

In accordance with this theory, therefore, the *electricity* which descends into the auroral belt is the *primary cause* of the greatest part of the terrestrial current, and, through this, of the many variations of the magnetic elements. There are also others, as the diurnal changes in the temperature on the earth's surface, but the *chief cause* is, in my opinion, the electric current from the atmosphere.

In my belief, therefore, the possibility of explaining the peculiarities of this phenomenon lies in a thorough and complete knowledge of the current from the atmosphere.

SELIM LEMSTRÖM
Professor of the Helsingfors University
(To be continued.)

THE FLORA OF ANCIENT EGYPT¹

THE discovery made by Emil Brugsch Bey on July 6, 1881, in the vault of a king of the twentieth dynasty is of the greatest importance to botany in consequence of the large number of species of plants contained in the offerings and funeral repasts and in the wreaths which adorned the illustrious dead. Among them are several which were not known to belong to ancient Egypt. I have begun the study of the remains of these plants taken from the breasts of the most celebrated kings of Egypt and of such inestimable value to science. Leptured by Mr. Maspero to arrange these relics for the Egyptian Museum of Boulak, I have classified them according to the high personages for whom they were intended. On the eight cardboards which I have the honour to send you in the name of Mr. Maspero, you have a part of the funeral wreaths belonging to Ramses II., Amenhotep I., and Aahmes I.

The wreaths of Ramses II. were renewed towards the end of the twentieth dynasty (1100 or 1200 B.C.), or at the time of the twenty-first dynasty (1000 B.C.). The king of that period, according to records inscribed on the coffins and translated by Mr. Maspero, caused a new coffin to be made for the great Ramses, the one in which he had first been placed having been accidentally destroyed. In this new coffin were several yards of wreaths, which Mr. Maspero handed to me. I have examined them all and ascertained their composition.

The wreaths of Ramses II. are formed of the leaves of *Mimusops Schimperi*, Hochst., either folded or torn in

¹ "Memoir on the Discovery at Deir-el-Bahari in Relation to the Ancient Flora of Egypt," by G. Schweinfurth. [This article, written in French, was communicated to Sir Joseph D. Hooker by Dr. Schweinfurth, together with a set of the wreaths, flowers, &c., described therein. These objects were exhibited at the annual *savoir* of the Royal Society on the 25th ult., and are now on view in No. 3 Museum, Royal Gardens, Kew. With regard to the orthography of the names of the Egyptian kings, that employed by some of the leading Egyptologists of this country has been adopted in this translation. Thus Amenhotep has been substituted for what looks like Amenhotpan in Dr. Schweinfurth's manuscript.—W. B. HEMSLEY.]

See "La Trouvaille de Deir-el-Bahari," 20 photogr. par M. E. Brugsch. Texte par G. Maspero. (Le Caire: chez F. Maurès et Cie. 1881.)